their range considerably. In the clearings in Flying Fish Cove and on the shore-terrace it is interesting to note that nearly all the secondary growth consists of a small tree, *Melia azederach*, which at the time of my first visit was represented by two or three examples only, and these had most likely been introduced by man. In other parts of the island clearings are often occupied by great numbers of seedlings of *Inocarpus edulis*; this is one of the consequences of the extinction of the rats, which formerly fed largely on the fallen fruits of this tree.

"Much time was spent in collecting the marine fauna, especially of the reef at Flying Fish Cove, and I hope that reports on some of the groups will be published shortly."

The following papers were read:—

1. Preliminary Account of the Life-history of the Leaf-Insect, *Phyllium crurifolium* Serville. By H. S. Leigh, Honorary Research Fellow in the University of Manchester.*

[Received December 23, 1908.]

(Plate XXVIII.†)

The present paper is intended to form a preliminary account of the life-history of a Leaf-Insect, *Phyllium crurifolium*‡ Serv. from the Seychelles Islands. I have had this species under observation during the past year, and although I have been able to note several facts of interest in connection with the development, many of the more important details remain to be worked out.

It was thought, however, that notwithstanding the fragmentary nature of my observations up to the present time, some account of this remarkable insect might prove interesting, and it is on this consideration that the following preliminary account has been written.

My study of *P. crurifolium* has been carried on in the Zoological Laboratories of the Manchester University, and also in the hot-houses at my own residence in Worsley.

I had neither sufficient material nor apparatus for making a complete study of the insect and its development during the past year. The work will be continued, however, during the coming season, and with abundant material at my disposal I hope to complete the details of the study and publish the results in a fully illustrated memoir.

During the autumn of 1907 I received a hundred ova and some

* Communicated by Professor S. J. Hickson, F.R.S., F.Z.S.

† For explanation of the Plate see p. 113.

‡ Kirby (1904) includes this species in his genus *Pulchriphyllium*.

thirty young larvæ of *Phyllium crurifolium* from Mr. St. Quintin, F.Z.S., and it is owing entirely to his kindness in presenting them to me and also in furnishing me with a few of the more important suggestions as to the conditions necessary for successfully rearing them, that I have been able to observe the habits of the insects in confinement.

The eggs that I received were laid by insects which Mr. St. Quintin had reared during the winter of 1906 and 1907, and he is, I think, the first naturalist who has *bred* the Leaf-Insect in this country. The original stock was brought from the Seychelles to England in the spring of 1906 by Lord Crawford.

The genus *Phyllium**, which constitutes the tribe Phylliides and includes all the Leaf-Insects, comprises perhaps some of the most extraordinary of all living insects; their wonderful similarity to vegetable structures has often aroused the admiration of naturalists, but it is only upon gaining a more complete knowledge of their life-histories that we can fully appreciate this most astonishing example of "Protective Resemblance." It is not a matter of much surprise that the Leaf-Insects were thought at one time to be of a vegetable as well as of an animal nature. This imaginative belief has given rise to several peculiar ideas, and one prevalent notion amongst the people in those countries which these insects inhabit is, that the insect is in reality a changed leaf that has adopted the strange practice of walking (de Borre, 1883).

The genus of Leaf-Insects was thought in the time of Linnæus to consist of only one species; this was named *Mantis siccifolius* (1767), and was figured by Rösel (1749). Stoll (1815) gave figures of two species, whilst Serville (1839) mentions three species in his 'Histoire Naturelle des Orthoptères.' In 1843 Gray described thirteen species, many of which were new, and Westwood (1859) mentions fifteen species. Joly (1871) described more fully than any previous author the natural history and anatomy of *Phyllium crurifolium* Serv.; and later, in 1887, Brongniart gives a short account of the development of *Phyllium siccifolium* Linn. Since that time very little appears to have been written until 1903, when Morton's paper "Notes sur l'élevage des Phyllies" was published; and quite recently two short papers have been written by St. Quintin: one "Leaf-Insects in Captivity" (1907), and the other "Notes on the Life-history of the Leaf-Insect" (1908).

Apart from these, little work appears to have been done recently, and our knowledge of the life-history of the Leaf-Insect is still meagre.

The first living examples of *Phyllium* were brought to this country in 1854. The bringing of living specimens was attended with some difficulty, but Mrs. Blackwood, who was greatly

* Kirby (1904) includes three genera in his subfamily Phylliinæ, viz. *Chitoniscus*, *Pulchriphyllium*, *Phyllium*.

interested in these strange insects whilst in India, attempted to bring some back with her; she received some eggs in 1854 which hatched in due course, and Murray (1856) gave an account of a specimen which was reared to maturity in the Royal Botanic Gardens of Edinburgh. Prior to this, I believe the transformations and habits had not been watched by any naturalist.

The Phylliums are peculiar to the Old World, being mostly confined to the islands of the Indian Ocean, and they would seem to have a special predilection for insular life. Several species inhabit the Seychelles and Ceylon, whilst others occur in Mauritius, Borneo, Java, Celebes, and the Philippines, and some are reported to extend as far as the Fiji Islands. One species, *Phyllium scythe*, is recorded from the mountainous regions of Northern India.

The eggs of the Leaf-Insect have been studied in Europe on several occasions: by Murray in 1855, Joly in 1871, Henneguy in 1890, and others—they all speak of their great resemblance to seeds. The egg of *Phyllium crurifolium* is about the size of a sweet-pea seed and resembles very closely the seeds of certain umbelliferous plants. Murray, speaking of *P. scythe*, says: "If the edges of the seed of the *Mirabilis jalapa* were rubbed off, the seed might be mistaken for the egg." The egg—which is in reality a capsule containing the egg—is of a brown colour, somewhat barrel-shaped, with five longitudinal ribs, all of which are equal distances apart, except two between which the space is wider. The surface of the egg is rough and cork-like, and there is usually an irregular row of small pits in the spaces between the longitudinal ribs. The large space is much smoother and flatter than the other portion of the egg, and in the centre there is a groove of an oval form extending almost from the apex to the base and enclosing a small scar or hollow which I believe has been compared to the hilum in seeds. At the apex of the egg a conical lid or stopper is attached, whilst the base is slightly concave.

The capsule of the egg appears, without the aid of a lens, to be of a rather fibrous nature, but when examined with a microscope the true porous texture is revealed. If, as Murray says, this outer covering had been of a firm substance, the embryo insect could not have received the amount of air and moisture necessary for its existence. Moisture and warmth are two extremely important factors in the development of *Phyllium*, and certainly if the eggs were surrounded with a compact substance the young insect could not develop. As in most Phasmidæ, the eggs are not glued on to surrounding objects, but are deposited loosely and fall through the foliage to the ground where they remain for some time before hatching; they are retained for a few minutes between the gonapophyses of the female after their extrusion from the oviduct and are afterwards shot out to some distance. In some cases ova were found three feet or more from the female.

This habit of discharging the eggs no doubt ensures a better distribution of the offspring, as the females are extremely sluggish creatures, and if the eggs were simply dropped they would in all probability be clustered together in masses and fall an easy prey to their enemies.

It is necessary when rearing the Phylliums in captivity to provide abundant moisture as well as heat for the ova. They were placed in an orchid house where a temperature varying from 65°–85° F. was maintained, the atmosphere being also exceedingly moist.

Under these conditions the ova began to hatch about the end of August 1907, the first larva appearing on August 28th, and they continued to hatch very irregularly until the end of January 1908. Although the majority of the larvæ appeared during September, October, and November, I found that their emergence depended to a great extent upon a high temperature; none hatched unless the temperature exceeded 70° F. Morton and St. Quintin each speak of this irregularity in the hatching of the eggs, and the latter says that although his larvæ continued to emerge during several months, "the ova were all deposited between the 7th April and the 15th May."

I think it is very probable that the time passed in the egg stage is exceedingly variable and may be prolonged. In confinement embryonic development requires four to seven months for its completion. Apparently the larvæ emerge very irregularly in the Seychelles, for some were found in the early larval stages side by side with the adult insects.

The larva, when ready to emerge, pushes off the lid or stopper to which reference has already been made. When newly-hatched it is about 16 mm. in length and possesses the characteristic form of the Phylliums. The head and prothorax are reddish-brown; meso- and metathorax brown with a red dorsal line; flattened expansions of the abdomen reddish-brown, but marked with dark brown semicircular rings from the fifth to the tenth segments.

I found that the young larva takes no food until four days after hatching, and during this time it is rather active, moving about with a singular hesitating and staggering action, which is even accentuated if the insect is alarmed.

The plant upon which these insects principally feed is the *Psidium guava*, but in Ceylon they are said to feed also on the leaves of the tea and certain species of lemon trees.

This question of food probably offers one explanation for the young larvæ fasting a few days, as the chances are it would be extremely difficult for them (on emerging from the eggs lying on the ground) to climb up the stems of their food-plant through the thick and entangled vegetation and obtain food at once.

Not being able to procure any of the natural food-plants, I followed the example of Mr. St. Quintin and placed my young larvæ on oak leaves which I found they took to well; they require, however, to be provided with plenty of moisture, and to

ensure this, I sprayed them once a day with tepid water. It was most interesting to see the thirsty larvæ eagerly drinking the drops as they hung from the leaves and branches after the spraying.

As the autumn advanced the leaves of the oak became less nutritious, and it was necessary to find another substitute for the larvæ. Again following the advice of Mr. St. Quintin, I placed the larvæ on small bushes of the evergreen oak (*Quercus ilex*) and on this they settled down very well.

The rate of development, *i. e.* the time occupied between the deposition of the eggs and the appearance of the imago, depends very largely upon the temperature. I have not yet been able to work out the exact length of the various larval stadia, but have determined their approximate lengths, and I should think that under favourable circumstances the whole development would be completed in ten or eleven months.

The Leaf-Insect is Paurometabolous and corresponds to the general rule in the Orthoptera. The larvæ in all stages are on the whole similar to the adults and there is no very abrupt transition, development taking place by a gradual increase in size. In the newly-hatched larva neither tegmina nor wings are present, these being acquired during the later stages, but only attaining their full dimensions in the imago state. There is no pupal stage, the larva merely passing through a slight resting stage prior to its reaching the perfect condition. I found that there are six or seven larval stadia, so that the number of ecdyses is six or seven. Murray gave three as the number of ecdyses in *Phyllium scythe*, and if this is correct it appears curious there should be such a discrepancy in the number of moults in the Phylliums.

The larvæ moult for the first time when about six weeks old if kept in a mean temperature of 66° F., the succeeding moults following at intervals varying from five to six weeks.

The colour of the newly-hatched larva is, as previously stated, reddish-brown streaked with dull red, but this soon changes and the larva passes through a regular series of colorations from brown to green during the first fortnight. In the first day or two of larval life hardly any change is noticeable excepting the slightly paler colour; but when the insect is a week old a yellowish-green colour is assumed which gives place in about a fortnight to a beautiful pale green on the dorsal and to a rich glossy green on the ventral side. Later, as the larvæ increase in size, their colour becomes more varied and, although green predominates, many shades occur. Some individuals are beautifully marked with different shades of brown and yellow. These colours combined with the positions assumed by the larvæ render them most inconspicuous on the leaves.

Nor is the resemblance to plant-life confined to colour, for the larva has a very peculiar gait which imitates to a remarkable degree the shaking of the leaves rather than the movements of an insect. The larva of the second stadium is about 20 mm. in

length, but apart from size differs little from that of the previous stage. The sexes, so far as I could see, were indistinguishable at this stage.

In the third stadium the external sexual characteristics first make their appearance. The females are somewhat larger than the males, the former being 28 mm. in length, the latter about 26 mm., whilst the flattened expansions of the abdomen are slightly broader in the females than in the males. The future wings of the male, although at present very insignificant, may now be seen in the form of two small processes on the metathorax; these being entirely absent in the females. Further, the legs of the male larvæ are beautifully mottled with irregular patches of brown and yellow, those of the female being generally without these decorative markings. The fourth larval stadium is characterised by increased sexual dimorphism; the male is about 33 mm. in length and 19 mm. in greatest breadth; the antennæ have now increased a little in length, being 3 mm.; and the future tegmina and wings are present in the form of processes about 4 mm. and 2 mm. long respectively. The female is larger and of a somewhat rounder shape; length 35 mm., breadth 19 mm. The femora of the prothoracic legs are of wider proportions than those of the male, whilst the femora of the mesothoracic legs have, in the middle of their posterior lobe, a brownish spot which is seldom present in so decided a form in the male larvæ. The future tegmina may be noticed in the shape of two small processes, about $1\frac{1}{2}$ mm. in length; the antennæ remain short, in contrast to those of the male. The sexual dimorphism becomes gradually more pronounced at each of the succeeding stadia, and reaches its fullest significance in the adult condition. In the penultimate stage the sexes are very dissimilar; the male is about 55 mm. in length, 25 mm. in greatest breadth; has moderately long antennæ; the future tegmina and wings are well defined as two pairs of dorsal appendages, and the expansions of the prothoracic legs are comparatively small. The female is altogether much larger, being about 70 mm. long and 35 mm. broad; has short antennæ; only one pair of dorsal appendages (tegmina), and the foliaceous expansions of the prothoracic legs are very large.

The larvæ throughout their lives are diurnal, but seem to show a decided partiality to feeding during the first and last hours of daylight; food is taken at other times of the day, but a decided preference is shown (at all events in the earlier larval stages) for the twilight. As the sun sinks below the horizon and the light fails the larvæ begin operations by a number of preliminary swinging movements, after which they move in a very hesitating fashion in search of food; having discovered the leaves that are palatable to them, they feed with great avidity for fifteen or twenty minutes. At the end of this time darkness has usually set in and the larvæ once more settle down to await the morning, when the same operations are repeated.

I found that the last larval stadium is frequently prolonged

and lasts eight weeks in many instances. The last week of this stadium is spent in a rather torpid condition during which the larva takes little or no food. A few days before each ecdysis the larva (as in many species of insects) ceases to feed, and having secured a good foothold on the underside of a leaf remains motionless.

After each ecdysis the larva usually devours its cast skin except the legs, and then fasts for about twenty-four hours before recommencing to feed upon the leaves. It takes some time for a moult to be completed, and forty-five or fifty minutes generally elapse from the time of the old skin splitting to the time of the larva being entirely free. The whole process of moulting appears, however, in the Phylliums to be most curious and would take much too long to describe in such an account as the present.

The sexes differ so much in the adult state that they would perhaps hardly be recognised by the uninitiated as belonging to the same species. The males are much more slender and of smaller dimensions than the females, and they do not retain the marvellous leaf-like appearance which characterises the latter. The length of the male varies from 60 to 70 mm. The head is somewhat quadrangular, generally of the same colour as the remainder of the body, and possesses two or three red ocelli which are situated between and slightly behind the level of the bases of the antennæ. The eyes are rather globular and very prominent. The antennæ—which are placed between the eyes—are pilose and very long, often attaining 32 mm.; they are composed of twenty-four joints which are smaller near the head, becoming gradually larger in the middle and finally small again at the extremities. When in motion the insect carries the antennæ forward either in a horizontal or semi-vertical position, but when at rest they are placed backwards as shown in the figure.

The prothorax is heart-shaped and tapers a little toward the posterior end. The mesothorax is broader than the prothorax and carries the tegmina, which are 13 mm. long and of parchment-like consistence. The latter—which only cover a small portion of the wings—are green but frequently spotted with brown or red. The metathorax is of about the same width as the mesothorax and bears two large membranous wings which extend when folded almost to the posterior end of the body. The wings are of delicate texture and are furnished with a regular network of nervures and nervules; in repose they fold up like a fan. They are marked in several places with small dark red streaks.

The first three abdominal segments become successively broader until the maximum width of 24 mm. is reached in the fourth abdominal. At each side of this segment there is a circular transparent spot surrounded by a brown ring, and from here the body becomes gradually narrower, finally terminating in a bifid protuberance. The abdomen is exceedingly flat, and the

laminated expansions are generally pale green on the dorsal and rich emerald-green on the ventral side. The colour, however, varies considerably in different individuals, some being darker green than others, and I have seen one or two quite yellow specimens. The legs with the exception of the prothoracic femora are entirely brown, and being prettily decorated with many shades of yellow look rather like small pieces of decaying leaves. The expansions of the prothoracic femora are of a green and brown colour; they are elegant in shape and, compared with those of the female, are very small.

The females are much larger and more unwieldy creatures than the males. They attain a length of from 95 to 100 mm. The head is large; not quite so quadrangular as in the male and is devoid of the red ocelli. The eyes are much less prominent than in the male, and the antennæ are very short, being composed of only nine segments.

The prothorax takes the form of a shield with a slight furrow in the centre. The mesothorax becomes much broader than the prothorax and bears the remarkable leaf-like tegmina. The latter, which generally remain in a state of repose, are of a most remarkable structure and remind one of leaves to their minutest detail. They are large and ample, being 54 mm. in length, and generally cover the greater part of the abdomen. Each tegmen is similar to half a leaf and has on its internal side a large nervure from which at intervals smaller nervures emanate; these in turn giving off subordinate veins which form a complete ramification throughout the whole structure. The leaf-like form of the tegmina is carried still further since they are adorned with many irregular rust-coloured markings similar to those often found on leaves.

The metathorax is broader than the mesothorax and attains at its posterior end a breadth of 18 mm. The hind wings, which are so conspicuous in the male, are represented in the female by two very small processes, covered by the tegmina and entirely hidden from view.

As in the male, the first three abdominal segments become broader in regular sequence until the maximum width of about 44 mm. is reached in the fourth abdominal segment; from this there is a gradual tapering of the segments to the posterior end which terminates in a bifid protuberance. The abdomen of the female, although possessing flat expansions of considerable size, is very bulky compared with that of the male, and even increases in volume as the ova mature. The general colour of the abdomen is green of varying tints, and it is almost impossible to describe one colour as applicable to all or even to many individuals. Perhaps pale leafy-green is the commonest colour of the dorsal side whilst the ventral is rich emerald-green. St. Quintin says he has "bred some entirely yellow and several of a crushed-strawberry colour, while a few were of an amber-brown."

Similar spots to those which were found on each side of the

fourth abdominal segments of the male occur also in the female, but instead of being transparent they are often opaque and of a brownish-red colour. The first three abdominal segments are generally ornamented at their edges with brown markings, and there is frequently a brown patch at each side of the seventh abdominal segment. Further, there is often an interrupted brown mediodorsal line extending from the sixth abdominal segment to the anal extremity.

The femora of the prothoracic legs are very large and foliaceous, having flat expansions which are green with many brown and yellow markings. The mesothoracic legs are also of moderate size, and on the posterior lobe of each femur there is a large and conspicuous brown spot. All the legs, however, have these laminated expansions to a greater or less degree and the general appearance of a female is that of a leaf.

Becquerel and Brongniart (1894) have carried out spectroscopic investigations on the colouring-matter of the Phylliums with a view to ascertaining whether it presented the same optical characters as the chlorophyll of leaves. They found that the spectrum of the Phylliums scarcely differs from the spectrum observed through living leaves, but slight distinctions were seen when compared with solutions of chlorophyll.

The majority of the males assumed the imago state long before the females. The first male appeared on March 8th, 1908, and others followed at irregular intervals until May and June, when the maximum number was reached. From this time there was a gradual diminution in the number of males. The first female emerged on May 22nd, 1908. They continued to appear until the end of August. Morton (1903) speaks of his first male as appearing about six weeks before the first female, and says that nearly all the males were dead when this individual appeared. St. Quintin (1907) also notes that his first male emerged one month before the first female. I do not know whether the majority of the males arrive at maturity before the females in the Seychelles, but from the foregoing evidence such a state of affairs seems quite possible.

The males are very active and are quite capable of flying a few yards. Their activity is increased after dark, when they usually move briskly over the leaves and occasionally fly from one bough to another. Being so agile they are rather difficult to handle, and if touched generally drop or take a short flight to some neighbourhing object. The females, on the other hand, are very sluggish insects and seldom move far. They are quite unable to fly, and if from any accidental cause they lose their foothold, can only ease the fall by means of their tegmina which spread out like a parachute.

The life of the male is of about four or five weeks duration and food is taken as in the larval stages. The females are much longer lived and survive eight or nine weeks at least; they eat much more than the males and consume in this period an

immense quantity of foliage. The male generally selects his mate during the night, and copulation takes place at some time between 8 a.m. and 3 p.m. the following day. The sexes are united for at least two hours.

I have not been able to ascertain so far the exact number of eggs produced by one individual, but think that from eighty-five to a hundred is the probable number.

Summary.—The Phylliums are dependent upon a very warm and moist atmosphere, and are therefore more or less confined to the islands in the tropical zone: in all stages they are very similar, both in colour and habits, to various plant-structures. Post-embryonic development is slow and takes place by a gradual increase in size of the individual, adults only differing externally from the young larvæ in the possession of fully developed tegmina and wings. The sexual dimorphism is pronounced, the females being large and foliaceous, whilst the males are much smaller and although flat are not characterised by such a leaf-like appearance as the females.

In conclusion, I wish to express my indebtedness to Professor Hickson and Mr. Hewitt for their kind assistance.

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EXPLANATION OF PLATE XXVIII.

Phyllium crurifolium.

The figures represent the adult male and female of the natural size, and were photographed from living examples.

1. Female imago.
2. Male imago.

2. The Mammals of Matabeleland. By E. C. Chubb, F.Z.S., Acting Curator of the Rhodesia Museum.

[Received December 29, 1908.]

The Rhodesia Museum has acquired during the past two years sufficient material to give a good idea of the mammalian fauna of the Western Province of Southern Rhodesia, and it is upon this collection that the present paper is based. For the sake of completeness, however, I have included the mounted examples of big game that were in the Museum prior to this period, and also a few species known to occur in the country, though up to the present unrepresented in the Museum.

The only previous paper dealing with the mammals of this area is that of De Winton *, being a list of a collection made by Selous at Essexvale. The species therein recorded are also incorporated in this list.

Two interesting Bats, *Rhinolophus empusa* and *Clœotis percivali*, are now recorded for the first time from South Africa south of the Zambezi, hitherto being known only from the type localities, Nyasaland and British East Africa respectively.

The probability of the different geological formations supporting distinct vertebrate faunas was pointed out to me some time ago by my former colleague, Mr. F. P. Mennell, and indeed this seems to be borne out in a remarkable way by at least one group among

* P. Z. S. 1896, p. 798.